Changkat Changi Secondary School

UNIT 3B

Dynamics & Pressure

Name: _____

Class: _____

Date: _____

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NOTES 3B.1

LESSON OBJECTIVES

At the end of the lesson, you will be able to:

- Describe what a force is
- Describe some types of forces
- Describe how a force changes the motion of a body

What is a Force?

We encounter many different types of forces in our day-to-day tasks, but how do we define what a force is?

DEFINITION:

> A force is defined as a push or pull that one object exerts on another.

RECALL: What is weight? Is it a type of force? What is the SI unit of weight?

In fact, the SI Unit of **ALL** forces is newtons (N).

Types of Forces

There are many different types of forces around us – are you able to name some of them?

The list below summarises some of the forces that we encounter:

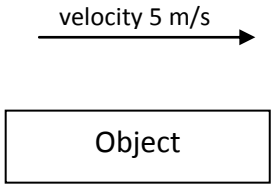
- _____ - Gravitational pull of Earth on an object.
- _____ - This force opposes motion, and exists when the surface of two objects are in contact / rubbing against each other.
- _____ - Similar to friction, as it opposes motion, but is due to air molecules rubbing against the surface of another object.
- _____ - The force between electric charges.
- _____ - The force between magnets / magnetic materials.

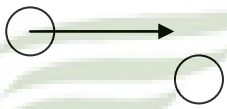
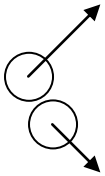
Effects of Forces

Given that we are not able to see forces, we can only identify forces by observing the effects of the force on the objects that it is acting on.

<table>
<tr><th>Effect of Force / Example</th><th colspan="2">Diagram
(Draw on the diagram a force, which will cause the effect stated)</th></tr>
<tr><td>A force can cause a stationary object to start moving (to the right)

Example:
A stationary soccer ball moving off in the direction it was kicked.</td><td colspan="2"> 
</td></tr>
<tr><td>A force can cause a moving object to increase its speed or to decrease its speed.

Example:
-Being pushed by a friend on a swing (increase speed)
-Braking to slow down/stop a bicycle (slowing down)</td><td colspan="2"> 
</td></tr>
<tr><td>A force can cause a moving object to change its direction of motion.

Example:
Pool balls hitting against one another during a game of pool</td><td>BEFORE
  </td><td>AFTER
  </td></tr>
<tr><td colspan="3">A force can deform an object.

Example:
Crushing an empty coke can</td></tr>
</table>

NOTES 3B.2

LESSON OBJECTIVES

At the end of the lesson, you will be able to:

- Describe the effects of balanced and unbalanced forces acting on a body
- Make use of the relationship F = ma to solve related problems.
- Identify and draw the forces on an object, using a free-body diagram.

Balanced Forces

In Notes 3A.1, we encountered forces of equal magnitudes, acting in opposite directions on an object, thus giving a zero resultant force. We described this case as balanced forces acting on an object.

When the forces are balanced (i.e. no resultant force), there will not be any acceleration on the object. For example, a book resting on the table will remain stationary (since the forces are balanced), and a ball will continue rolling at a constant speed, unless a force acts on the book/ball. This leads us to Newton's 1st Law.

> **Newton's 1st Law** states that an object at rest will remain at rest, and an object in motion will remain in motion, unless a resultant force acts on the object.

Unbalanced Forces

But what if there is a resultant force, i.e. the forces are not balanced? In that case, because of the resultant force, we will be able to observe on the effects of the forces, as we have looked at in Notes 3.1 (eg. A stationary object starting to move, or a moving object slowing down).

In Case #1 and #2 of Notes 3.2, the forces were unbalanced, and we can apply Newton's 2nd Law.

> **Newton's 2nd Law** states that when a resultant force acts on an object of a constant mass, the object will accelerate and move in the direction of the force.

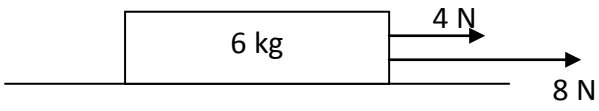
Newton's 2nd Law is summarised by the following equation:

$$F = ma$$

Where: F = resultant force (N)
m = mass of object (kg)
a = acceleration (m/s^2)

EXAMPLE

Two forces of magnitude 8N and 4N are acting on a block of mass 6kg as shown in the diagram. Find the resultant force, and the acceleration of the block.



(a) Resultant force =

(b) Resultant acceleration =

EXAMPLE

A car of mass 1000 kg accelerates from rest to 20 m/s in 5 s. Calculate:

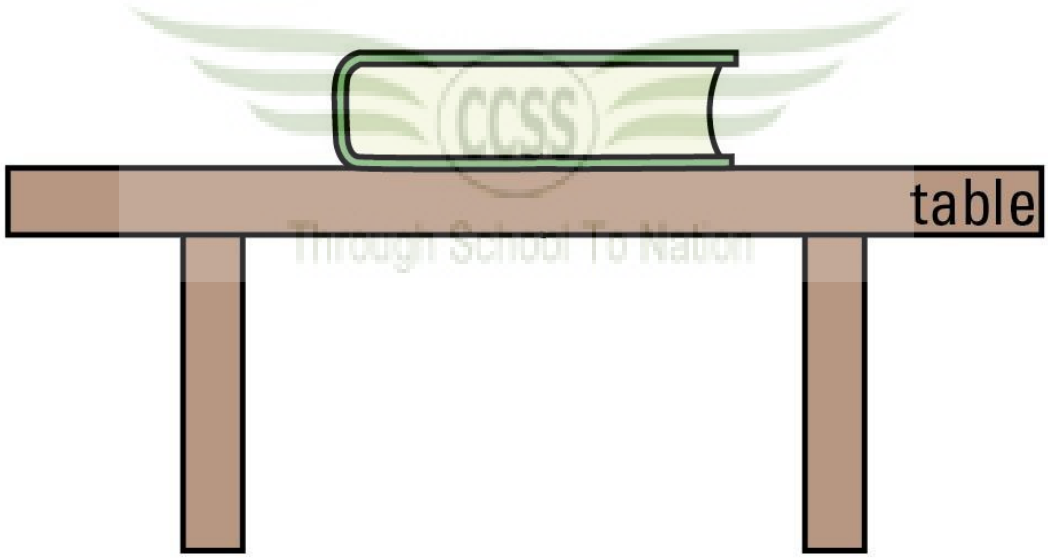
(a) the acceleration of the car,

(b) the forward thrust of the car.

Newton's 3rd Law

There is also a Newton's 3rd Law, which states that for every action, there is an equal and opposite reaction force, and these forces act on mutually opposite bodies.

To demonstrate Newton's 3rd Law, we identify the forces acting on a book resting on a table. Since the book is not moving, we know that the forces acting on the book must be balanced (i.e. no resultant forces acting on it).



NOTES 3B.3

LESSON OBJECTIVES

At the end of the lesson, you will be able to:

- Describe the effects of friction on the motion of a body

Friction

Friction is present in our daily lives. It is the force that allows us to walk on the ground, and is the force that slows a car down when the brakes are applied.

Friction always opposes motion between two surfaces in contact.

Friction is the result of non-smooth surfaces. If a surface was perfectly smooth, it would be frictionless. Unfortunately, this is hardly the case when we look around us.

Uses of friction

- Needed for walking or holding a pair of chopsticks
- Used in braking pads to slow down cars
- Car tyres
- Parachutes
- Rock climbing

Example

A 5 kg box on an unknown surface is shown below.

When a horizontal force is applied increasingly to it, the box begins to move only when the force exceeds 5 N.

(a) Explain why the box moves only when the force exceeds 5N.

_____

(b) The horizontal force is now increased to 15 N and the box moves at a constant acceleration. Label on the diagram the magnitude and the direction of **ALL** the forces acting on the box.

(c) Hence, calculate the acceleration of the box.

Negative effects of friction

- Causes wear and tear of moving parts in engines, motors and machines
- Friction reduces efficiency of cars by up to 20%.
- Air resistance slows down movement of objects.

Air Resistance

Another type of friction is _____. In this case, air molecules rub against different materials, and thus acts as a type of frictional force. In the case parachuting, parachutes make us of air resistance to slow down the speed of a parachutist. The large surface area of the parachute allows the parachutist to descend safely.

Ways to reduce friction include

- Wheels
- Ball Bearings
- Lubricants and polishing surfaces
- Air cushion e.g. hovercraft and magnetic levitation in trains

NOTES 3B.4

LESSON OBJECTIVES

At the end of the lesson, you will be able to:

- Define the term *pressure*
- Recall and apply the relationship $pressure = \frac{force}{area}$ to solve related problems.

What is Pressure?

In Physics, pressure is the measure of the force acting on a particular area. It is given by the following formula:

Where p =
F =
A=

From the formula, the smaller the area, the higher the pressure, and vice versa.

Test Yourself!

What are the units of pressure based on the formula above?

Example

A man, of mass 65kg, wears a pair of shoes with a surface area of 3 x 10^{-2} m^2. Calculate:

(a) the weight of the man

(b) the pressure that the man exerts on the ground.

Example

A rectangular block measures 30 cm by 5 cm by 10 cm weighs 37.5 N. Calculate the least and the greatest pressure it exerts.

(**Hint**: If it exerts the greatest pressure, will it have the largest or smallest area?)